BESH

WATER QUALITY OF MORRISON LAKE

Town of Gravenhurst

District Municipality of Muskoka

May 1976

Ministry of the Environment
Ontario

P. G. Cockburn
Director
Central Region

WATER QUALITY

OF

MORRISON LAKE

Town of Gravenhurst
District Municipality of Muskoka

Report Prepared by
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Technical Support Section

The Bacteriology Part of the Study (Field Evaluation and Report) was carried out by the Microbiology Section, Laboratory Services Branch, M.O.E.

Field Survey-1975

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INTRODUCTION

The pressure for additional development, the concerns of the Morrison Lake Ratepayers Association regarding the present condition of the Lake, and the lack of water quality data for Morrison Lake resulted in a water quality survey of the Lake being conducted in 1975. The intent of this survey was to define the Lake's existing water quality and provide a basis for determining the impact of subsequent development on the aquatic environment. The data obtained was used to calculate a simplified phosphorus budget, and the effect of further development on this budget was examined. The present report outlines the results of the study.

DESCRIPTION OF THE STUDY AREA

Morrison Lake is located in Wood Ward, Town of Gravenhurst, District Municipality of Muskoka. The nearest population centre, the Town of Gravenhurst, is located approximately 8 kilometers north-east of the Lake (Figure 1).

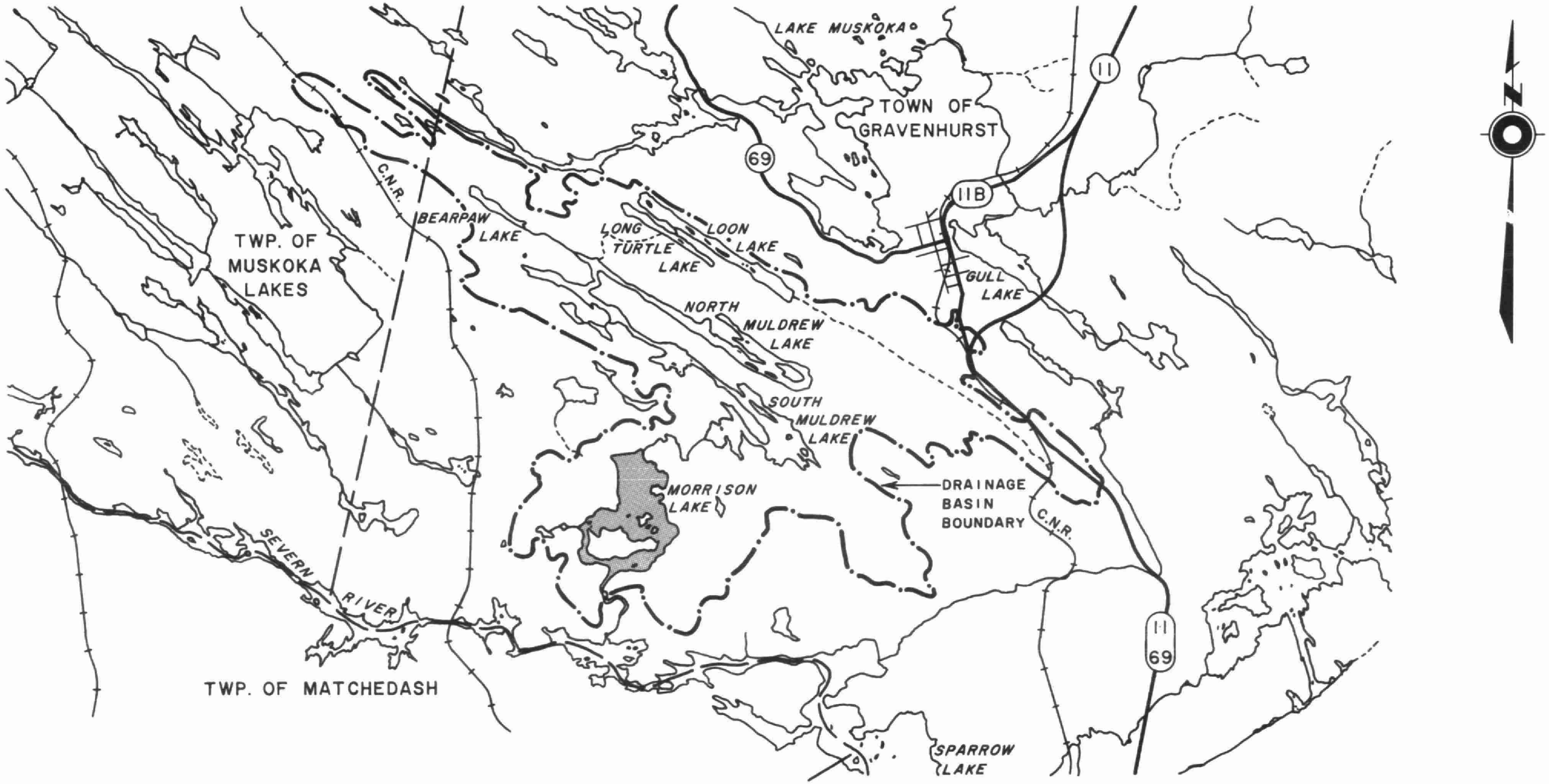
Morrison Lake is situated in the Pre-Cambrian Shield physiographic region, which is characterized by granitic bedrock with thin overburden. The topography of the drainage basin is gently rolling hills interspaced by swampy areas.

The Lake's physical characteristics are tabulated below:*

Surface area	2.5 km^2
Maximum depth	18 m
Mean depth	4 m
Volume	$10 \times 10^6 m^3$

*Ministry of Natural Resources

FIGURE 1 - GEOGRAPHIC LOCATION OF MORRISON LAKE



1 .5 0 1 2 3 4 KILOMETRES

1 1/2 0 1 2 MILES

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The total drainage basin area of the Lake is 64 km^2.** It is a complex drainage basin and includes numerous other lakes: North Muldrew, South Muldrew, Bearpaw, Long Turtle, Loon, plus roughly a dozen smaller unnamed lakes. A significant proportion of the drainge basin is composed of marsh or swampy areas. The major route for surface water movement is indicated below.

LOON ⟶ LONG TURTLE $\xrightarrow[\text{(Intermittent)}]{\text{Morrison Ck.}}$ N. MULDREW ⟶

S. MULDREW $\xrightarrow{\text{Morrison Ck.}}$ MORRISON LAKE $\xrightarrow{\text{Morrison Ck.}}$

SEVERN RIVER ⟶ GEORGIAN BAY

Morrison Creek enters the north end of Morrison Lake and flows out at the southern tip of the Lake. The Lake's other inlet is a small intermittent stream which drains two small unnamed lakes. This stream enters the west shore of the Lake, opposite the tip of Mile Island (see Figure 2). A lack of flow data for Morrison Creek complicated the determination of the Lake's flushing rate, however, it is estimated that the Lake flushes between 2 and 3 times per year.***

There are 179 cottages and one marina located on the Lake plus 55 vacant registered shoreline lots, 24 of which are on the mainland and 31 on the islands. Recreational activities enjoyed by the Lake's residents include swimming, boating, water skiing and snowmobiling.

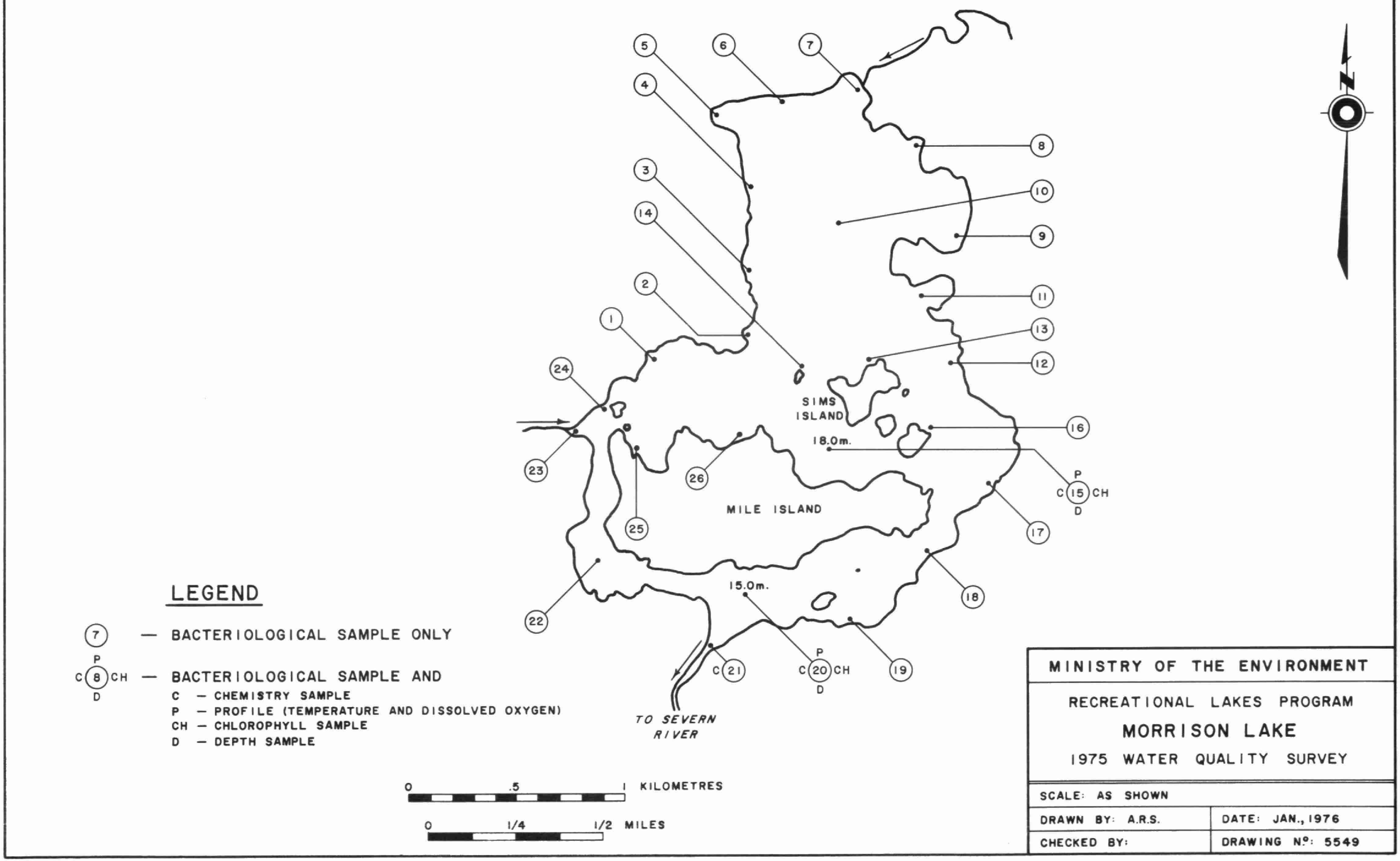
SURVEY PROCEDURES

Chemical and Biological

Four stations on the Lake were sampled on eleven separate occasions from May 12 to September 25, 1975, (Figure 2):

**Ministry of Transportation & Communications
***Based on expected areal runoff (7)

FIGURE 2 – SAMPLING STATION LOCATIONS, MORRISON LAKE



1. Station 7 - inlet station located at the mouth of Morrison Creek (receiving drainage from Muldrew Lake).

2. Station 15 - lake station located in the centre of the Lake's deepest basin. Depth - 18 m.

3. Station 20 - lake station located in the centre of the Lake's secondary basin. Depth - 15 m.

4. Station 21 - outlet station located in Morrison Creek (flowing to Severn River).

The following activities were conducted during each visit to the two lake stations:

a) temperature and dissolved oxygen profiles were recorded using an EIL Model 15A dissolved oxygen meter, which was calibrated prior to each run using the azide modification of the Winkler method. Additionally, the dissolved oxygen concentrations in a surface and bottom (1 m off bottom) water sample were determined using the Winkler method to verify the meter's readings.

b) water transparency was measured using a Secchi disc (30 cm. diameter disc divided into alternative black and white quadrants).

c) samples for mineral, nutrient and chlorophyll a determinations were secured as composites through the euphotic zone (calculated as twice the Secchi disc depth). This was accomplished by lowering and raising an 800 ml bottle through the predetermined depth of the euphotic zone at a rate allowing complete filling as the bottle was retrieved to the surface. The chlorophyll a samples were treated with 1 ml of a 2% suspension of magnesium carbonate. If these samples could not be delivered to the MOE Lab within

24 hours, the samples were filtered using a 1.2 u millipore filter, and stored in plastic containers until Lab delivery.

d) samples for mineral and nutrient determinations were taken 1 m off the bottom using a Van Dorn bottle.

A grab sample was collected at the inlet and outlet station, during each visit, for mineral and nutrient determinations. An additional sample was collected at the inlet station for chlorophyll a analysis.

Chemical analyses performed on each water sample included total and soluble phosphorus, Kjeldahl, nitrate, free ammonia and nitrite nitrogen, total iron, alkalinity and hardness, conductivity, pH and colour. All chemical analyses including chlorophyll a determinations were done according to standard techniques utilized by the Water Quality Section, Laboratory Services Branch, M.O.E.

Bacteriological

Timing

Bacteriological surveys were carried out from May 22 to May 26, and July 17 to July 21. These 5-day sampling periods, during which samples were collected daily at many lake stations, provide a reproducible bacteriological picture of the Lake.

Selection of Sample Locations

Bacteriological samples were collected from the outlet, the 2 inlets and 2 open-lake stations in addition to 22 shoreline locations considered to be representative of the various degrees of shoreline development found on the Lake (Figure 2). Samples were taken one meter below the surface at all stations, as well as one meter above

the bottom at two of the open-lake stations (Stns. 15 and 20).

Bacteriological Tests and Interpretation

The number of bacteria in each of the four kinds of 'indicator' organisms were determined on each sample.* The four kinds of bacteria, total coliform, fecal coliform, fecal streptococcus bacteria and Pseudomonas aeruginosa are all indigneous to man and other warm-blooded animals, and are found in the colon and feces in tremendous numbers. Many diseases common to man can be transmitted by feces; consequently, the probability of occurrence of these diseases is highest in areas where the water is contaminated with fecal material. These indicator organisms in water connote the possible presence of disease causing organisms.

In addition, the density of heterotrophic bacteria was determined at five locations considered to be representative of the whole lake. Heterotrophic bacteria require some organic carbon source for their growth and their density varies in proportion to the trophic status of the lake[1].

The data obtained was evaluated by statistical techniques in the following manner. The geometric mean, the most appropriate central value, and standard deviation were calculated for the values of each of the four kinds of bacteria at every station, providing concise valid data. Statistically significant variations in the bacterial densities between stations, or groups of stations was determined by a One Way Analyses of Variance and Bartlett's Test of Homogeneity. By these means the data from each station were tested against that of every other station until all stations with similar geometric mean densities were separated into groups (Group A, B).

*Methodology used is available upon request from the Microbiology Section, Laboratory Services, M.O.E.

The group results and those for individual stations, were identified by different stippling. Within each stippled area the group geometric mean applied for each type of bacteria, unless otherwise indicated by individual station values. The areas of better or worse bacterial densities were defined by the group geometric mean densities, and so any inputs of bacterial contamination, and the area they affect, were identified.

The effect of present development on the lake can be estimated by comparison of developed and undeveloped sections of the lake, and by comparison to an undeveloped lake[8].

EXISTING WATER QUALITY

All field data obtained, with the exception of temperature, dissolved oxygen and bacteria, are outlined in Tables 1 to 6. Unless otherwise specified, all discussions refer to both lake stations.

Temperature and Light Characteristics

A stable thermocline did not form at the lake stations until the latter part of the summer, though varying degrees of thermal stratification were evident except on the first sampling date (May 12). The maximum recorded temperatures at one meter below the surface, and at one meter above the bottom were 25.5°C and 6.4°C respectively (Figures 3 and 4). The thermal properties of the Lake are comparable to those of a second-class lake of Hutchinson (4).

The degree of transparency measured by means of a Secchi disc, fluctuated from 2.0 to 3.5 meters and averaged 2.9 meters. There was no appreciable difference between readings taken at the two lake stations.

The average colour of euphotic zone water samples was 35 Hazen units. This reflects the slight brown water colouration. Although a correction factor for colour has not yet been defined, this degree of colouration would cause only a slight decrease in Secchi disc readings, compared to a very clear lake (e.g. Skeleton Lake).

Water Chemistry Characteristics

Morrison Lake is a typical soft-water Pre-Cambrian Shield lake, having low hardness, alkalinity and conductivity values as shown in the following table:

	Stn. 15		Stn. 20		Stn. 7	
	range	mean	range	mean	range	mean
Hardness (mg/l as $CaCO_3$)	10-17	12	10-18	13	10-16	12
Alkalinity (mg/l as $CaCO_3$)	3-12	7	3-13	8	7-12	8
Conductivity (unhos/cm^3)	30-40	35	31-45	35	32-45	41

The pH values at both lake stations were consistently more acidic one meter above bottom, than in the euphotic zone. The bottom water and euphotic zone pH means were 6.1 and 6.4 pH units respectively. The mean pH value for the inlet (Stn. 7) was 6.3.

The euphotic zone iron concentration ranged from 0.15 to 0.38 mg/l, averaging 0.21 mg/l. There was no seasonal trend to the variation. High iron concentrations prevailed in the bottom waters, where, by the end of the survey a ten fold increase, over the original concentration measured in May, had occurred (refer to following table). A similar, but less pronounced increase occurred at the inlet, Station 7.

Total Bottom Water Iron Concentration(mg/l)

	Station 15	Station 20	Station 7
May 12	0.40	0.30	0.35
September 25	4.1	4.7	1.2

Dissolved Oxygen

The dissolved oxygen profiles measured at Station 15 were clinograde in character, and exhibited a negative heterograde condition within the metalimnion. Anoxic conditions prevailed in the bottom meter on September 25 (Figure 3).

The character of the dissolved oxygen profile at Station 20 was similar to that of Station 15, though the negative heterograde condition was less pronounced. Near anoxic conditions existed in the bottom meter on July 17, and by September 25, the lower 8 meters of this basin were anaerobic (Figure 4).

Nutrient Characteristics

The following table summarizes the total phosphorus concentrations measured at the two lake stations.

	Euphotic Zone [P] ug/l		Bottom [P] ug/l	
	mean	range	mean	range
Station 15	9	6-12	16	10-34
Station 20	9	6-13	21	10-40

The euphotic zone phosphorus concentrations were low, comparable to those measured in oligotrophic Pre-Cambrian lakes. The bottom water total phosphorus concentrations in Morrison Lake were considerably higher than the euphotic zone values. A maximum concentration of 40 ug/l was measured at Station 20 on September 25. The inlet's total phosphorus concentration was higher than that measured in the bottom waters; the concentration ranged from 12 to 53 ug/l, averaging 25 ug/l.

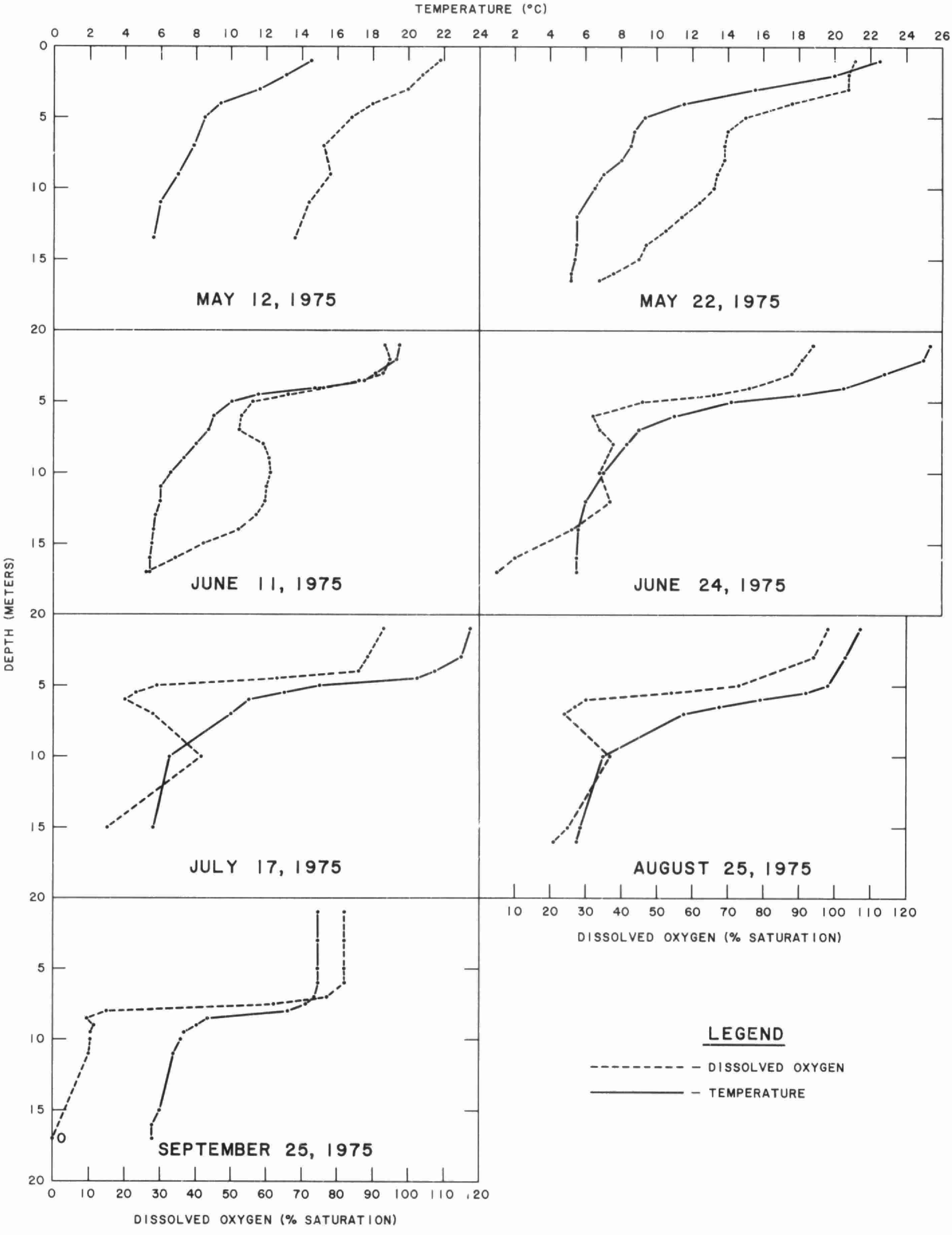


FIGURE 3 - DISSOLVED OXYGEN AND TEMPERATURE PROFILES, STATION 15, MORRISON LAKE

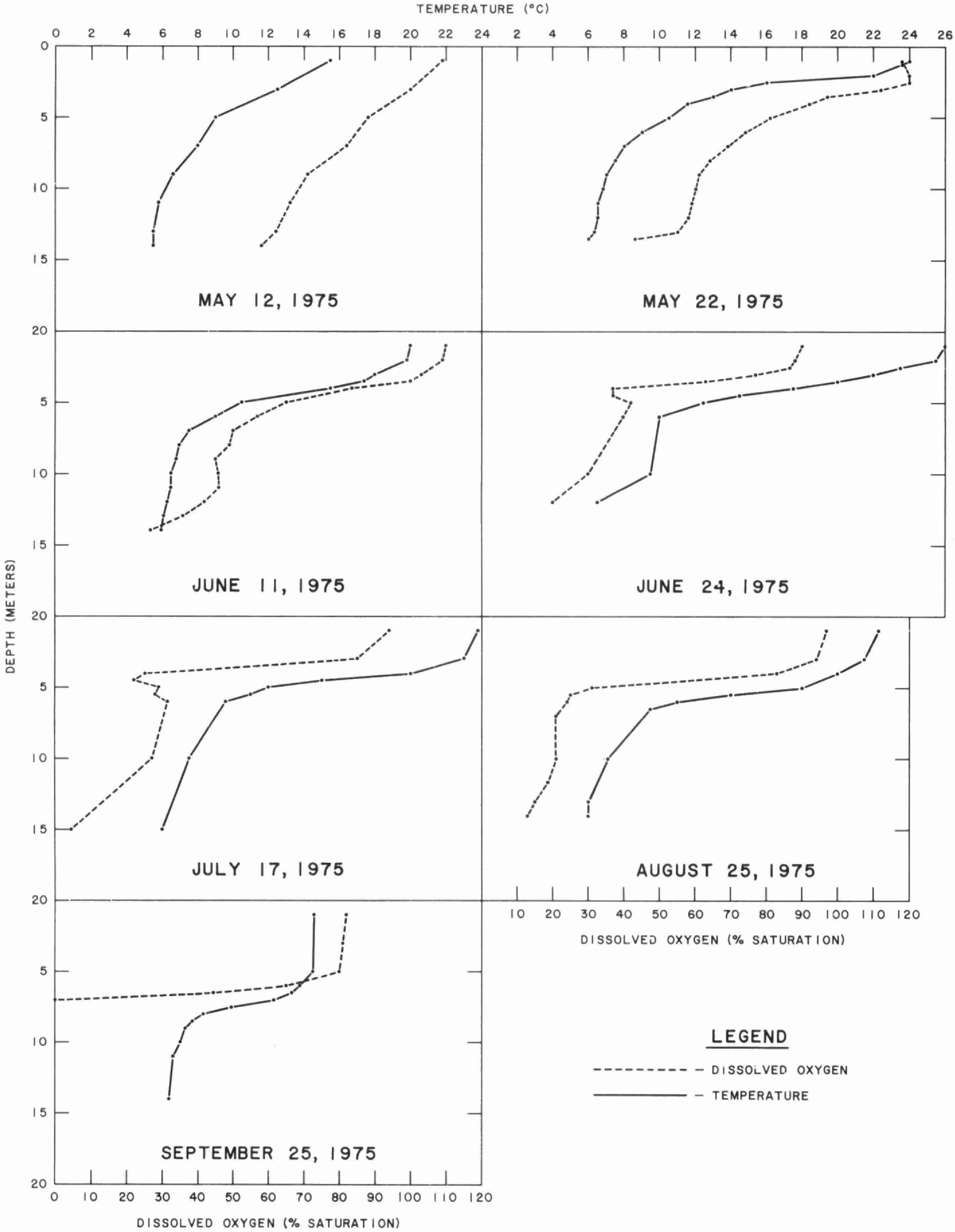


FIGURE 4 – DISSOLVED OXYGEN AND TEMPERATURE PROFILES, STATION 20, MORRISON LAKE

Moderate Kjeldahl nitrogen concentrations prevailed throughout the euphotic zone; ranging from 0.29 to 0.50 mg/l, and averaging 0.35 mg/l. Euphotic zone inorganic nitrogen concentrations were low, with NH_3-N and NO_2-N concentrations frequently at, or below the analytical limits of detection (10 ug/l and 1 ug/l respectively).

Bottom water Kjeldahl nitrogen concentrations were high, averaging 0.50 and 0.62 mg/l at Station 15 and 20 respectively, with accumulations evident at Station 20 during the latter part of the summer. A maximum concentration of 1.3 mg/l was measured at this station on September 25 (Figure 5). Concurrent with the Kjeldahl nitrogen increase at Station 20, was an increase in NH_3-N concentrations to a maximum of 0.75 mg/l on September 25. The bottom water NO_2-N and NO_3-N concentrations were low, though greater than those measured in the euphotic zone.

The Kjeldahl nitrogen concentrations at the inlet were high, averaging 0.69 mg/l and reaching a maximum of 2.2 mg/l on September 25. This was not accompanied by an increase in NH_3-N concentrations. The inorganic nitrogen concentrations were low, with the NO_3-N concentrations frequently below the analytical level of detection (10 ug/l).

<u>Chlorophyll a</u>

Suspended algal densities, as measured by chlorophyll <u>a</u> concentrations, varied considerably, over the duration of the study, as shown in the following table.

	[Chlorophyll a] ug/l range	mean
Station 15	2.1-21.0	6.0
Station 20	3.4-16.0	7.1
Station 7	2.4-39.0	7.9

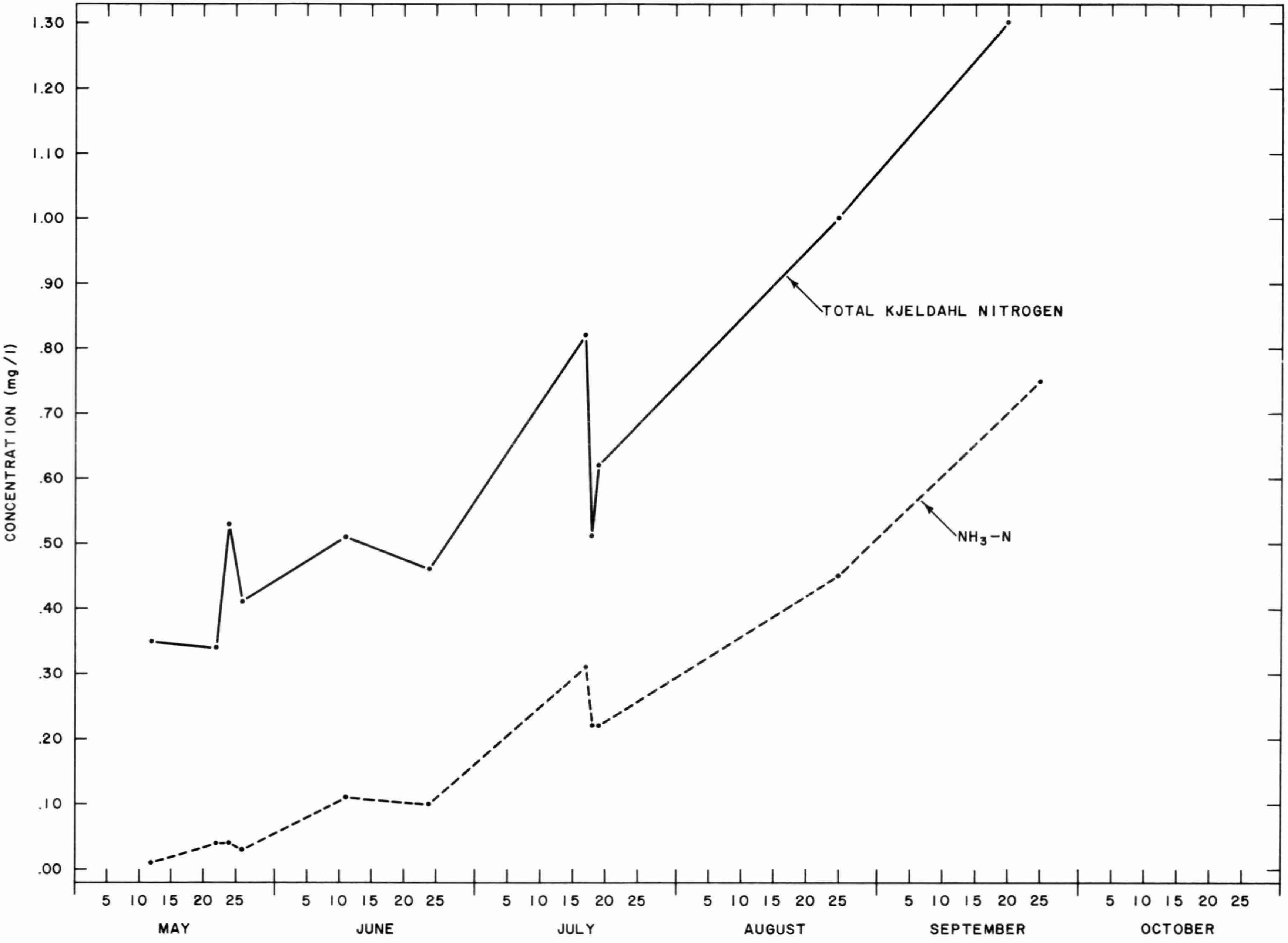


FIGURE 5 – BOTTOM WATER NITROGEN CONCENTRATIONS, STATION 20, MORRISON LAKE

The large variation in chlorophyll a concentrations at the lake stations is the result of an algae bloom, which spanned three sampling dates. The following table outlines these dates and the concentration measured at the two lake stations.

	[Chlorophyll a] ug/l	
	Station 15	Station 20
May 22	7.5	15.0
May 24	10.0	9.5
May 26	21.0	16.0

Removal of the spring bloom data reduces the range of chlorophyll a concentrations, and the mean values over the summer period to the following:

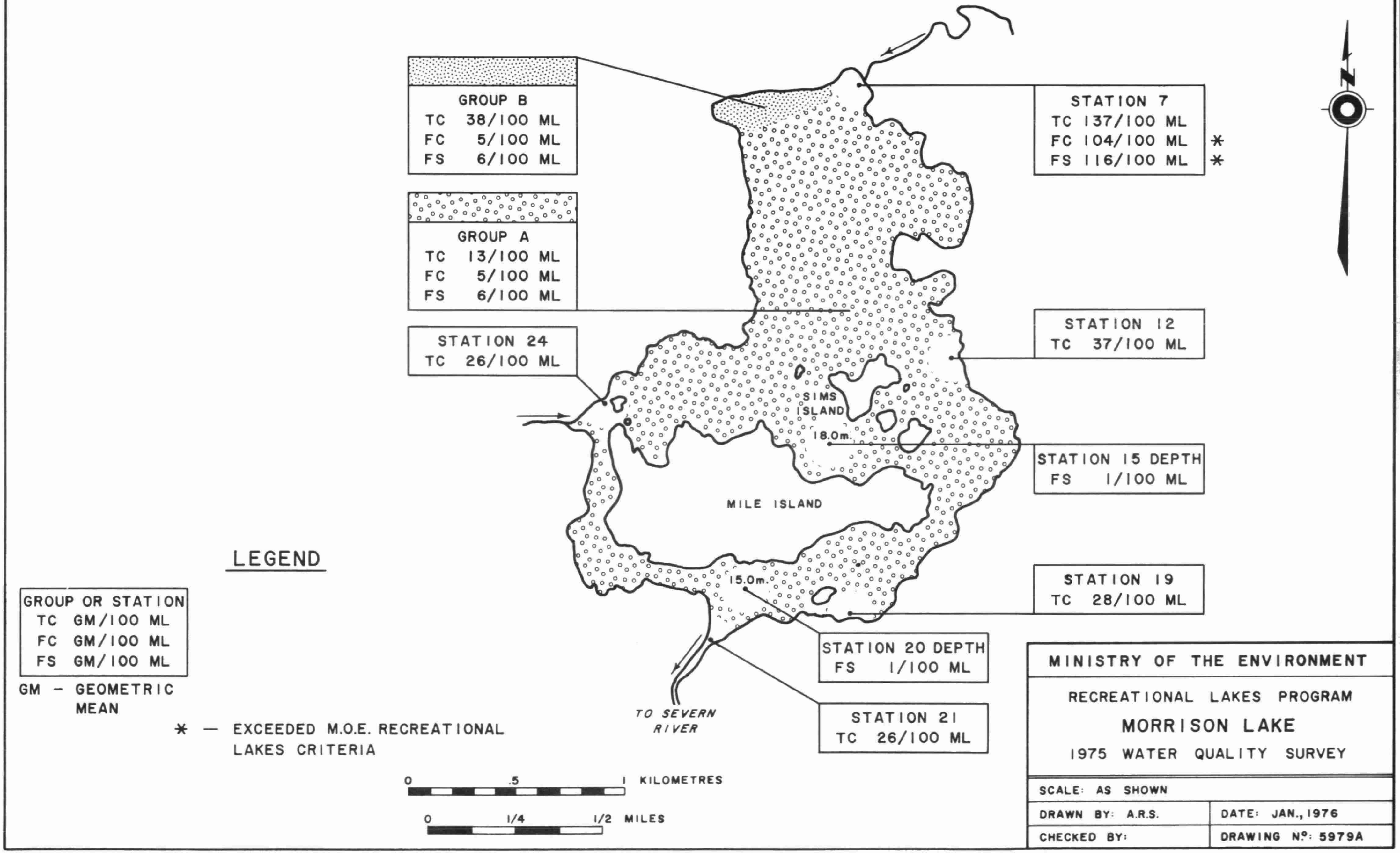
	[Chlorophyll a] ug/l	
	range	mean
Station 15	2.1-6.3	3.5
Station 20	3.4-6.3	4.7

Generally, during the summer period the lake stations were characterized by moderately high concentrations of suspended algae, but the potential exists for these concentrations to increase by several multiples, as demonstrated by the spring bloom data.

Bacteriology

During the May and July surveys the bacteriological quality of Morrison Lake was good, and well within the M.O.E. microbiology criteria for total body contact recreational use which states:

FIGURE 6 - DISTRIBUTION OF BACTERIA FOR THE MAY 22 TO MAY 26 SURVEY



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"Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC) and/or enterococcus (fecal streptococcus, FS) geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month including samples collected during weekend periods".*

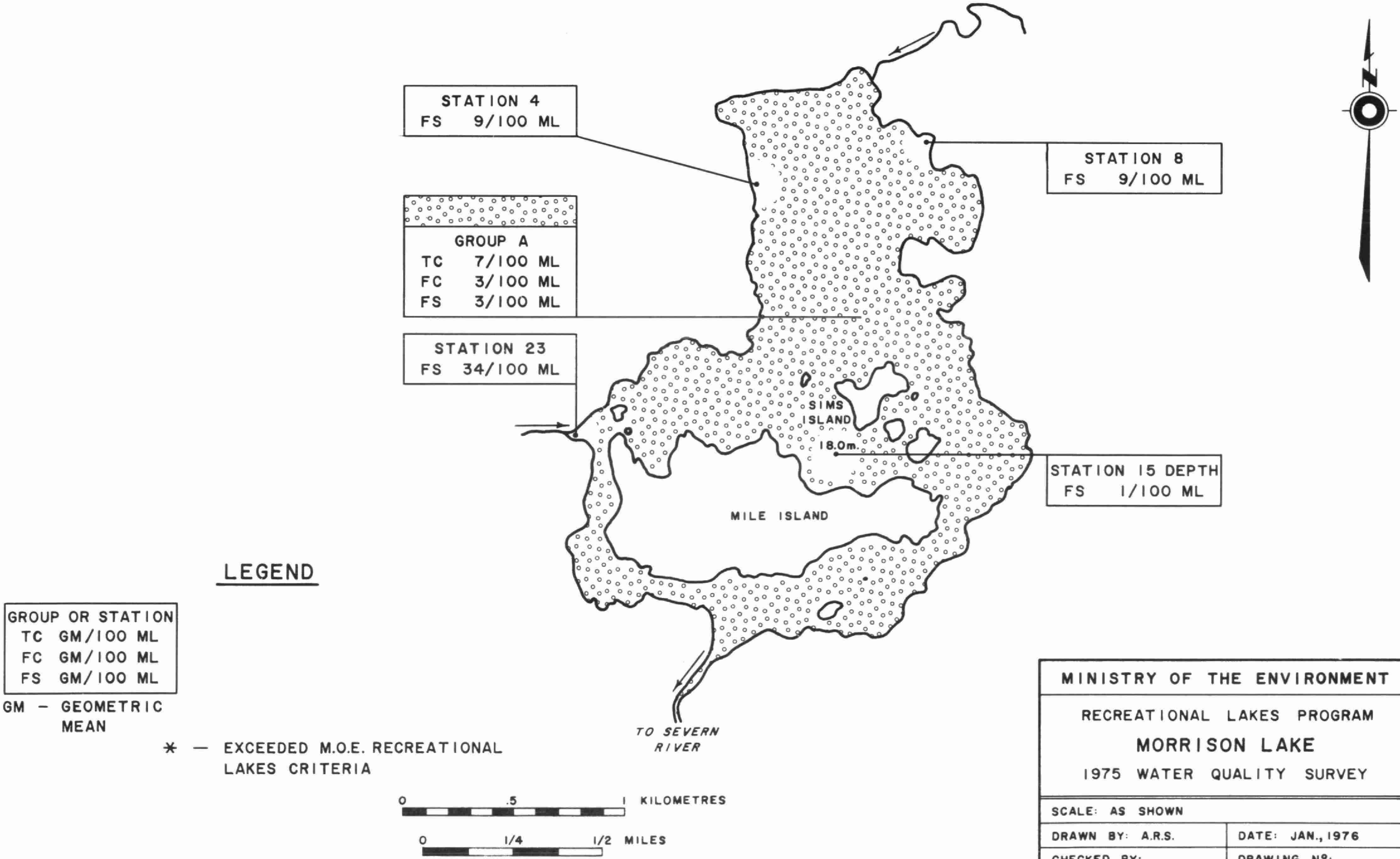
In the May survey, the geometric mean densities for the main body of water were 13 TC, 5 FC, 6 FS per 100 ml (Figure 6, Group A). Total coliform densities were low but higher levels were found at several scattered areas of the lake (Group B, and Stns. 12, 19, 21 and 24). The bottom waters of the midlake sampling locations (Stns. 15-D, 20-D) had lower fecal streptococcus levels of 1 per 100 ml. The northeastern inflowing stream (Stn. 7) had elevated levels of all the parameters with concentrations of 137 TC, 104 FC and 116 FS per 100 ml; these levels of fecal coliforms and fecal streptococcus exceed the M.O.E. criteria for total body contact. The ratio of fecal coliforms to fecal streptococcus (0.9:1) indicated that these bacteria were probably of animal or stormwater origin**. Inflows often have higher bacterial levels than the rest of the lake as they can carry materials such as soil, decaying matter and possibly animal and human wastes into the lake.

In the July survey, the bacterial densities for the main body of water were 7 TC, 3 FC and 3 FS per 100 ml (Figure 7, Group A). Two sampling locations on the northwestern shoreline (Stns. 4, 8) had a fecal streptococcus density of 9 per 100 ml, and the bottom waters of an open-lake station (Stn. 15-D) had a low concentration of 1 FS per

*Guidelines and Criteria for Water Quality Management in Ontario, 1974.

**Water Quality Guidelines for Bathing Beaches, Ministry of Health, 1975.

FIGURE 7 - DISTRIBUTION OF BACTERIA FOR THE JULY 17 TO JULY 22 SURVEY



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RECREATIONAL LAKES PROGRAM

MORRISON LAKE

1975 WATER QUALITY SURVEY

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100 ml. A western inflowing stream had a fecal streptococcus concentration of 34 per 100 ml, exceeding the M.O.E. microbiology criteria for total body contact recreational use.

During the May and July surveys, an experiment was conducted to determine the distribution of heterotrophic bacteria (HB) in the lake. In the May survey the aerobic heterotrophic bacteria geometric mean was 302 per 1 ml, while the eastern inflowing stream (Stn. 7) had an elevated level of 2150 HB per 1 ml. In the July survey, the geometric mean for the entire lake for the heterotrophic bacteria decreased to 219 per 1 ml (Figure 8). The heterotrophic bacteria were distributed more uniformly than the indicators of fecal pollution. A relationship has been established between the bacterial densities and the trophic status of several lakes studied by the M.O.E. in 1974. However, the densities of heterotrophic bacteria in Morrison Lake were much lower than were expected from the observed chlorophyll levels.

Pseudomonas aeruginosa was isolated at several sampling locations in low concentrations in both the May and June surveys.

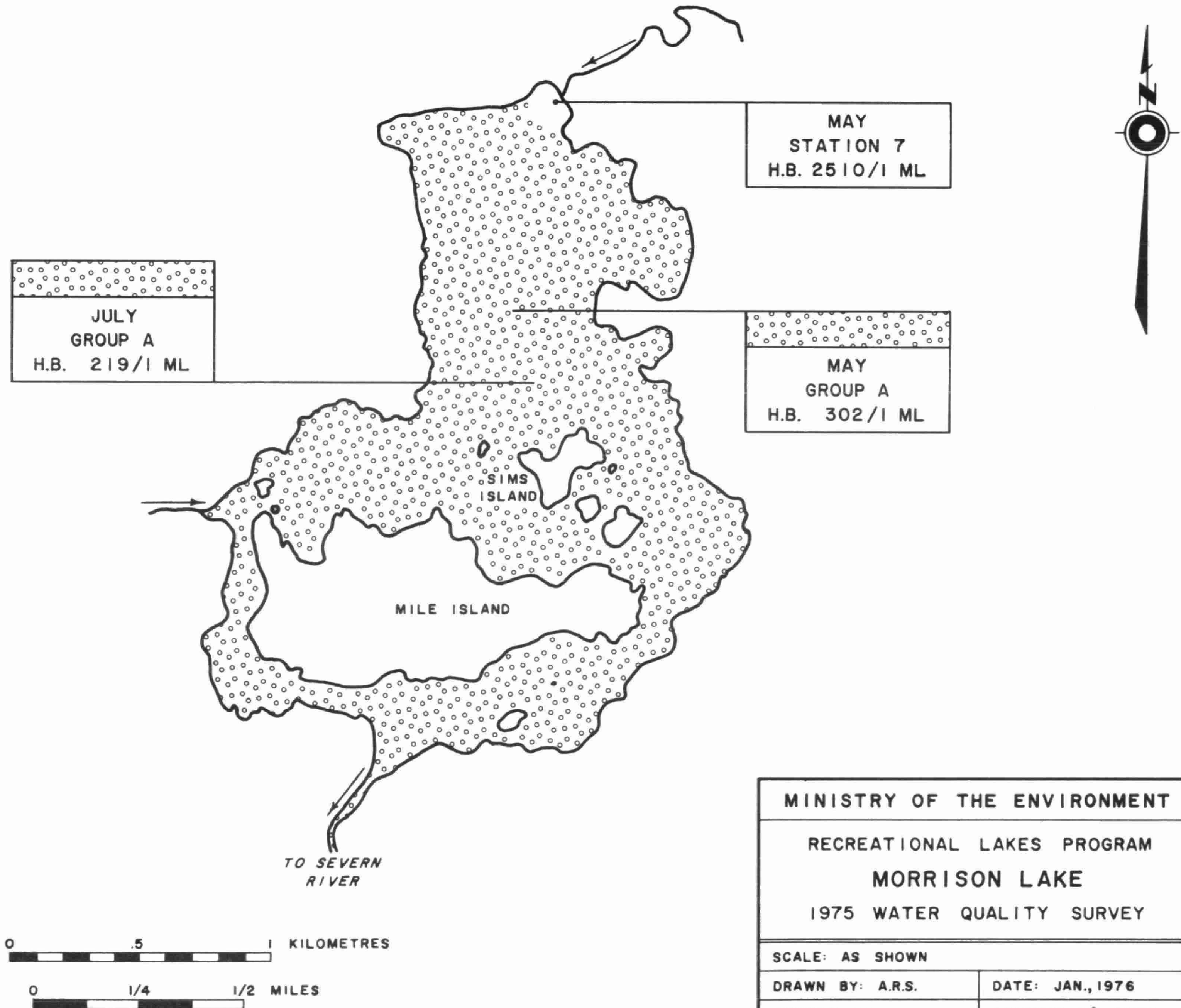
Effect of Present Development on the Lake

The effect of present development on the lake was not great, but the fecal coliform densities were higher than those in an undeveloped lake [8].

Overall Water Quality Status

The general status of a clear water lake, and a comparison with other lakes can be readily obtained by plotting the mean values for chlorophyll *a* and Secchi disc readings on a graph which has been derived by the staff of the

FIGURE 8 – DISTRIBUTION OF HETEROTROPHIC BACTERIA FOR THE MAY AND JULY SURVEYS



LEGEND

MONTH
GROUP OR STATION
H.B. G.M./1 ML

H.B. – HETEROTROPHIC BACTERIA
G.M. – GEOMETRIC MEAN

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Ministry of the Environment relating these two parameters. Although Morrison Lake is coloured, the degree of colouration present would only cause a slight decrease in the Secchi disc readings. Two chlorophyll a values have been used to plot the position of Morrison Lake on this curve:

1. the mean chlorophyll a value for the two lake stations over the duration of the study.

2. the mean chlorophyll a value for the two lake stations with the spring bloom data deleted (summer conditions).

Figure 9 illustrates the position of Morrison Lake relative to a number of other lakes in both the Pre-Cambrian and sedimentary areas of the Province. Morrison Lake is a moderately enriched, or mesotrophic lake, comparable in status to Stewart Lake.

Although the enrichment status of Morrison Lake is comparable to a mesotrophic lake, the following indicators of more advanced eutrofication are evident.

1. high accumulation of nutrients, particularly nitrogen in the bottom waters;

2. the occurrence of a short lived algal bloom in the spring.

Morrison Lake's present water quality status is primarily a result of the natural input of nutrients from its drainage basin. A significant proportion of the drainage basin is marsh or swamp areas of high nutrient content. The effect of these can be seen by comparing the nutrient

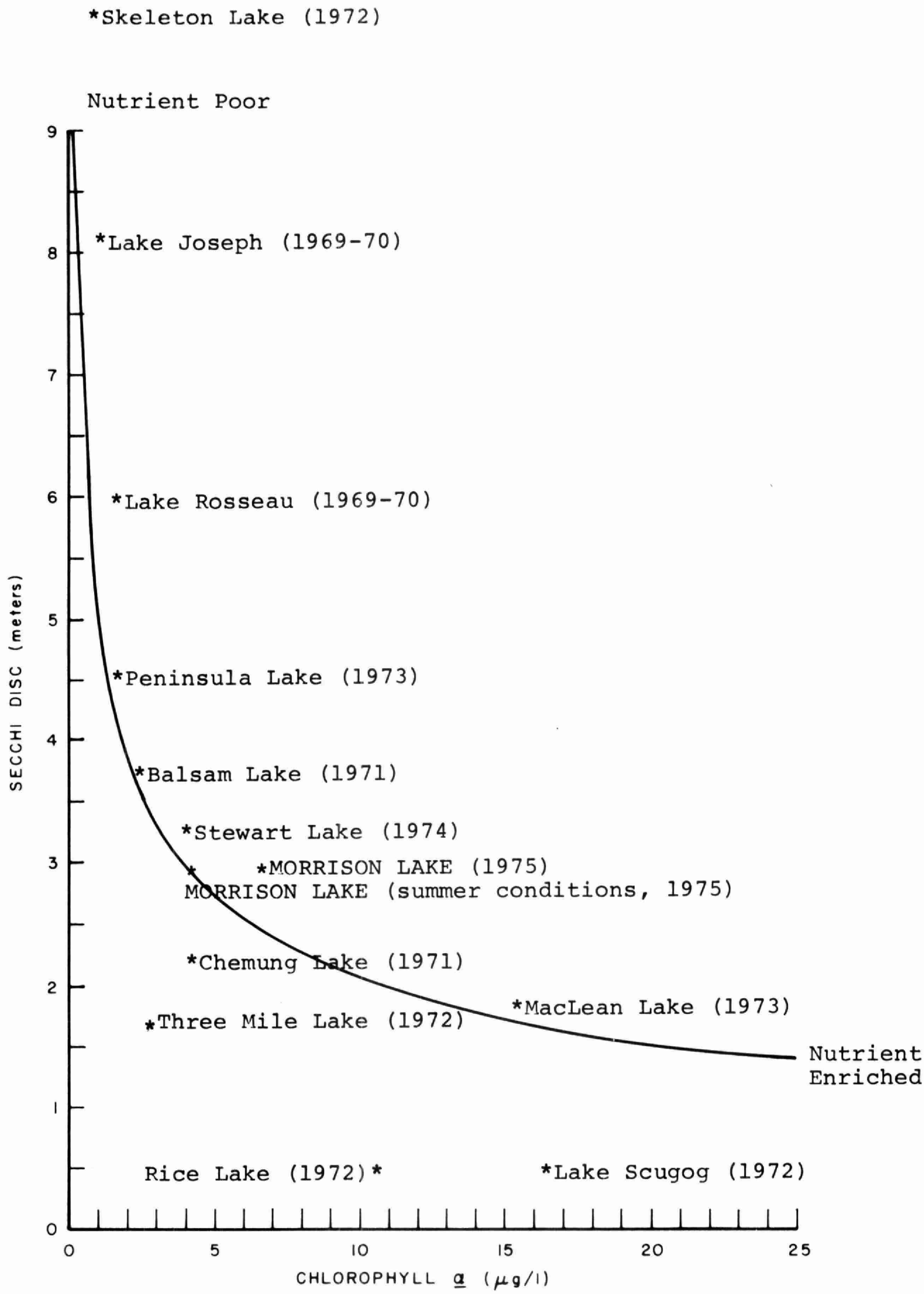

Figure 9 Mean Chlorophyll a and Secchi Disc Measurements in Morrison Lake, Relative to Other Ontario Lakes.

concentrations entering Morrison Lake via Morrison Creek, to those measured at the lake stations. Cottage development on the Lake, and other lakes within the drainage basins has undoubtedly affected the water quality, but this effect is small in comparison to that of the natural inputs.

Though enrichment problems do exist, the Lake still provides, and is expected to continue to provide, a hospitable environment for pursuit of water orientated recreational activities.

PHOSPHORUS BUDGET

Based on the water quality data obtained from this survey, a simplified phosphorus budget of Morrison Lake was calculated, utilizing gross inputs. This was done to obtain a comparative measure of the inputs. Based on this calculated budget, the effect of additional shoreline development was examined.

Two sources of phosphorus were considered in this budget:

a) the phosphorus originating from the Lake's drainage basin and entering the Lake via the inlet; the natural phosphorus input.

b) the phosphorus entering the Lake from the septic tank tile fields of existing cottages; the artificial phosphorus input.

a) natural phosphorus input

This was determined by multiplying the calculated outflow volume of the Lake, which was assumed to be equal to the inflow volume, by the mean measured total phosphorus concentration of the inflow. The calculations are shown below:

drainage basin area, $A_d = 64 \text{ X } 10_6 m_2$

runoff co-efficient, $r = 0.45 \ m^3/yr/m^2$

lake outflow volume, $Q = (A_d)(r)$
$= 29 \text{ X } 10^6 m^3/yr$

Therefore the inflow volume $= 29 \text{ X } 10^6 m^3/yr$

The mean total phosphorus concentration of the inlet, C_i = 25 ug/l

The natural phosphorus input $P_N = (Q)(C_i)$
$= 714$ kg/yr

b) artificial phosphorus input

This was determined by multiplying the number of existing cottages by the expected tile field phosphorus export value. A phosphorus export value of 0.4 kg P/cottage was used. Dillon's[(2)] revised estimate of the phosphorus export value for tile fields in the Muskoka area, based on 0.8 kg P/capita/yr and 0.76 capita years/cottage/year, is 0.61 kg P/cottage. Nicholls[(6)] determined the artificial phosphorus input from cottages on Harp Lake to be 0.28 kg/cottage. He cautions, however, that,

> "Clearly, a better understanding is needed of phosphorus dynamics in soils of the Pre-Cambrian Shield before artificial loadings of phosphorus to lakes from associated cottage development can be predicted with confidence."

Based on the above, a value of 0.4 kg P/cottage presently appears realistic for management purposes. The expected phosphorus export value for back lot establishments (lots with no lake frontage, e.g. second tier development) would be lower.

There are presently 179 cottages on Morrison Lake. The artificial phosphorus input is (179)(0.4) = 72 kg/yr.

Therefore, based on this simplified budget the total

phosphorus input to the Lake is 786 kg/yr, of which 91% is natural inputs, and 9% artificial inputs.

Effect of Additional Shoreline Cottage Development

Three cases of shoreline development were examined, and the effect that each would have on the Lake's phosphorus budget was determined. The results are summarized in the following table.

Case A: existing development plus the remaining 55 registered shoreline lots were developed

Case B: existing development plus an additional total of 100 shoreline lots were developed

Case C: existing development plus an additional total of 150 shoreline lots were developed.

PHOSPHORUS INPUTS

	Natural Kg/yr	Artificial Kg/yr	Total Kg/yr	Increase Kg/yr	% Increase
Present	714	72	786		
Case A	714	94	808	22	3%
Case B	714	112	826	40	5%
Case C	714	132	846	60	8%

These calculations indicate that 9% of the present phosphorus input to the Lake is attributable to the existing cottage development. Increasing the number of shoreline developments by 55 would result in a 3% increase in the total phosphorus input, and the cottages would be contributing 12% of the total input. An addition

of a 100, or 150 cottages would result in similar increases, as can be seen from the table.

Increased phosphorus inputs of these magnitudes would not be expected to adversely affect the water quality, aesthetics, nor existing uses of the lake.

SUMMARY - CONCLUSIONS - RECOMMENDATIONS

1. The chemical, physical and biological parameters indicate that Morrison Lake is mesotrophic, or moderately enriched. The Lake, however, does exhibit signs of advanced eutrophication; high accumulations of nitrogen were evident in the bottom waters during the latter portion of the survey, and a short lived algal bloom occurred in the spring.

2. The bacterial water quality of Morrison Lake in 1975 was good. The bacterial levels for the main body of water were low, whereas in May, the north-eastern inflowing stream (Stn. 7) had high levels of bacterial contamination of the type thought to be of animal or stormwater origin. The heterotrophic bacterial levels were lower than normally found in a lake of moderate chlorophyll levels. The bacterial effect of present development on the Lake was slight, as the fecal coliform levels were not significantly higher than those in an undeveloped lake.

3. Phosphorus budgets for the Lake, calculated using gross inputs indicate that 9% of the present total phosphorus input to the Lake is attributable to the existing cottage development.

4. Based on the calculated phosphorus budget, no adverse degree of impairment to the Lake's water quality, which would affect the existing uses, is expected to materialize due to additional development. Therefore, at this time, based <u>solely</u> on water quality considerations, additional shoreline or backlot development can be permitted on Morrison Lake.

5. It is recognized that water quality considerations may not be the major limiting factor for development on Morrison Lake. Other factors (e.g. socio-economic and other environmental concerns) may be of greater significance.

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TABLE 1: Analysis Results for Euphotic Zone Samples at Station 15

Date	Secchi Disc-m.	Chor. a-ug/l	Alk.-mg/l	Hardness-mg/l	Cond.-umhos/cm^3	T-Iron-mg/l	T-Phos.-ug/l	S-Phos.-ug/l	TKN-mg/l	NH_3-N-mg/l	NO_2/N-mg/l	NO_3/N-mg/l	pH	Colour-Hazen Units
12/5/75	2.0	6.3	11	14	30	.25	7	1	.32	*.01	.003	*.01	6.4	40
22/5/75	2.5	7.5	6	13	33	.20	9	1	.35	.03	.009	*.01	6.4	40
24/5/75	2.5	10.0	6	17	32	.20	10	*1	.37	.02	.003	*.01	6.5	30
26/5/75	3.0	21.0	6	17	31	.20	12	1	.50	*.01	.003	*.01	6.5	40
11/6/75	3.5	2.1	7	11	33	.20	10	2	.37	.01	.002	.02	7.1	20
24/6/75	3.0	2.2	3	12	32	.15	11	2	.35	.03	.002	*.01	6.1	20
17/7/75	3.0	3.7	6	10	37	-	8	1	.30	.02	.002	*.01	6.2	30
18/7/75	3.5	3.7	6	10	36	-	7	1	.33	*.01	.003	*.01	6.3	40
19/7/75	3.0	2.5	6	10	34	-	6	1	.29	.01	.002	.01	6.2	30
25/8/75	3.5	2.5	6	11	37	-	11	2	.40	.01	.004	.01	6.9	**70
25/9/75	2.7	4.6	6	11	34	.38	9	1	.29	.01	.002	*.01	6.6	-

**greater than

*less than

TABLE 2: Analysis Results for Bottom Water Samples at Station 15

Date	Alk.-mg/l	Hardness-mg/l	Cond.-umhos/cm^3	T-Iron-mg/l	T-Phos.-ug/l	S-Phos.-ug/l	TKN-mg/l	NH_3/N-mg/l	NO_2/N-mg/l	NO_3/N-mg/l	pH	Colour-Hazen Units
12/5/75	10	13	32	.40	11	1	.32	*.01	.003	.02	6.1	40
22/5/75	6	13	35	.65	15	2	.47	.11	.004	.06	6.1	40
24/5/75	7	14	35	.60	10	2	.43	.07	.004	.08	6.0	40
26/5/75	7	16	36	.60	15	2	.49	.09	.003	.06	6.5	50
11/6/75	10	12	37	.90	15	3	.54	.13	.003	.09	6.7	15
24/6/75	8	12	37	1.60	34	6	.71	.26	.006	.05	5.7	70
17/7/75	8	10	38	-	13	4	.45	.16	.014	.08	5.9	40
18/7/75	8	11	35	-	12	5	.44	.15	.012	.08	5.8	30
19/7/75	8	11	40	-	14	3	.56	.24	.012	.06	5.9	40
25/8/75	7	11	37	-	18	2	.36	.06	.003	.05	6.8	30
25/9/75	12	12	40	4.10	15	2	.75	.29	.006	*.01	6.1	-

*less than

TABLE 3: Analysis Results for Euphotic Zone Samples at Station 20

Date	Secchi Disc-m.	Chor. *a*-ug/1	Alk.-mg/1	Hardness-mg/1	Cond.-umhos/cm^3	T-Iron-mg/1	T-Phos.-ug/1	S-Phos-ug/1	TKN-mg/1	NH_3/N-mg/1	NO_2/N-mg/1	NO_3/N-mg/1	pH	Colour-Hazen Units
12/5/75	2.0	6.3	10	15	31	.25	10	2	.32	.01	.003	*.01	6.4	30
22/5/75	2.8	15.0	6	15	31	.20	11	1	.37	.04	.003	*.01	6.2	35
24/5/75	3.0	9.5	9	15	33	.20	11	*1	.40	.01	.003	.03	6.2	40
26/5/75	2.8	16.0	7	16	32	.20	13	1	.40	.01	.003	*.01	6.5	40
11/6/75	3.0	3.8	7	11	33	.20	9	2	.40	.01	.002	.01	6.7	30
24/6/75	3.2	4.0	3	11	32	.18	11	1	.35	.04	.002	.02	6.0	30
17/7/75	3.0	4.8	6	10	35	-	8	1	.36	.02	.002	*.01	6.2	35
18/7/75	3.0	5.8	7	10	40	-	7	1	.31	.02	.002	*.01	6.3	30
19/7/75	3.0	4.8	6	11	35	-	6	2	.32	.01	.002	.01	6.0	30
25/8/75	3.5	3.4	5	11	33	-	7	1	.29	*.01	.002	.01	6.7	30
25/9/75	2.7	5.0	6	11	33	.18	8	1	.29	.01	.002	*.01	6.6	-

*less than

TABLE 4: Analysis Results for Bottom Water Samples at Station 20

Date	Alk.-mg/1	Hardness-mg/1	Cond.-umhos/cm^3	T-Iron-mg/1	T-Phos.-ug/1	S-Phos-ug/1	TKN-mg/1	NH_3/N-mg/1	NO_2/N-mg/1	NO_3/N-mg/1	pH	Colour-Hazen Units
12/5/75	10	15	34	.30	10	2	.35	.01	.003	*.01	6.0	40
22/5/75	6	14	34	.35	12	1	.34	.04	.002	.09	6.1	30
24/5/75	8	15	34	.55	27	*1	.53	.04	.003	.07	6.0	40
26/5/75	6	14	35	.30	12	2	.41	.03	.003	.07	6.3	40
11/6/75	7	12	37	.80	15	2	.51	.11	.002	.08	6.2	45
24/6/75	6	12	35	.45	13	3	.46	.10	.004	.08	5.4	40
17/7/75	11	10	36	-	26	3	.82	.31	.004	*.01	5.9	**70
18/7/75	9	11	39	-	16	6	.51	.20	.007	.02	5.9	50
19/7/75	9	11	39	-	22	4	.62	.22	.006	.02	5.8	50
25/8/75	13	18	42	-	37	3	1.0	.45	.010	.01	6.6	**70
25/9/75	13	18	45	4.70	40	5	1.3	.75	.008	*.01	6.1	-

**greater than

*less than

TABLE 5: Analysis Results for Samples at Station 7

Date	Chor. a-ug/1	Alk.-mg/1	Hardness-mg/1	Cond.-umhos/cm^3	T-Iron-mg/1	T-Phos.-ug/1	S-Phos.-ug/1	TKN-mg/1	NH_3/N-mg/1	NO_2/N-mg/1	NO_3-N-mg/1	pH	Colour-Hazen Units
12/5/75	4.0	11	14	32	.35	13	3	.39	.20	.004	*.01	5.9	40
22/5/75	11.0	12	16	39	.80	38	2	.73	.12	.005	*.01	6.2	**70
24/5/75	8.4	8	15	36	.80	53	1	.81	.07	.004	*.01	6.5	**70
26/5/75	5.9	9	16	37	.50	17	2	.49	.01	.004	*.01	6.3	70
11/6/75	2.4	8	11	74	.65	22	3	.48	.03	.002	.01	7.9	40
24/6/75	6.1	8	12	37	.65	41	9	.69	.08	.004	.01	5.9	50
17/7/75	3.5	7	10	42	-	12	3	.38	.01	.003	.02	6.1	30
18/7/75	5.8	7	11	36	-	14	2	.40	.01	.003	*.01	6.0	30
19/7/75	3.0	8	11	37	-	14	3	.50	.01	.003	.02	5.9	50
25/8/75	8.1	7	12	39	-	27	2	.53	*.01	.004	*.01	7.0	35
25/9/75	29.0	7	15	45	1.20	14	2	2.20	*.01	.004	*.01	6.0	-

**greater than

*less than

TABLE 6: Analysis Results for Samples at Station 21

Date	Alk.-mg/l	Hardness-mg/l	Cond.-umhos/cm^3	T-Iron-mg/l	T-Phos.-ug/l	S-Phos-ug/l	TKN-mg/l	NH_3/N-mg/l	NO_2/N-mg/l	NO_3/N-mg/l	pH	Colour-Hazen Units
12/5/75	11	14	31	.25	7	1	.30	*.01	.003	*.01	6.5	40
22/5/75	9	20	33	.20	12	1	.52	.03	.002	*.01	6.7	40
24/5/75	7	15	31	.20	7	1	.34	.01	.003	*.01	6.3	40
26/5/75	6	15	31	.20	9	3	.36	*.01	.003	*.01	6.5	40
11/6/75	7	11	33	.25	11	2	.39	*.01	.002	.01	6.6	20
24/6/75	4	12	32	.15	8	1	.36	.01	.002	*.01	6.4	20
17/7/75	10	10	40	-	4	1	.29	*.01	.002	*.01	6.4	40
18/7/75	6	10	35	-	5	1	.36	.01	.002	*.01	6.4	20
19/7/75	7	10	35	-	8	2	.35	*.01	.002	*.01	6.4	20
25/8/75	5	10	-	-	7	1	.27	*.01	.002	*.01	6.8	20
25/9/75	6	11	34	1.5	7	1	.28	*.01	.001	*.01	6.4	-

*less than